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Survey of Aquatic Invasive Species in Selected Umpqua National Forest Lakes and Ponds

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SURVEY OF AQUATIC INVASIVE SPECIES IN SELECTED UMPQUA NATIONAL FOREST LAKES AND PONDS

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Yellow floating heart *(Nympohides peltata*) infestation in Willow Sump, Umpqua National Forest, August 16, 2011.

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ABSTRACT

Eleven lakes and ponds within the Umpqua National Forest were surveyed for invasive aquatic macrophytes, snails, bivalves, and crayfish during the summer of 2011. Yellow floating heart (*Nymphoides peltata*), an invasive floating leaf macrophyte species, was detected in Willow Sump within the Little River drainage. European ear snails (*Radix auricularia*), an invasive species present in several Umpqua National Forest waterbodies, were detected in Beaver Pond within the Steamboat Creek drainage. One native crayfish species, the signal crayfish (*Pacifastacus leniusculus*), was observed in Crayfish Lake within the Brice Creek drainage. Diverse assemblages of native plant species were observed in the lakes and ponds. The UNF and the Oregon Department of Agriculture are exploring ways to eradicate the yellow floating heart infestation in Willow Sump.

INTRODUCTION

Aquatic invasive species (AIS) cause significant ecological and economic harm to freshwater resources in the United States. Plant species such as Eurasian watermilfoil (*Myriophyllum spicatum*) and yellow floating heart (*Nymphoides peltata*), and animal species such as zebra mussels (*Dreissena polymorpha*) and New Zealand mudsnails (*Potamopyrgus antipodarum*) can displace native species, interfere with recreation, degrade fish habitat, and impair water quality. Costs associated with invasive aquatic plants and zebra mussels in the United States are estimated at $110 million and $1 billion per year respectively (Pimentel et al. 2005). Given the environmental and economic costs of AIS, it is important to prevent introductions and detect new introductions early while control or eradication efforts are more likely to be successful and less expensive (Rejmánek and Pitcairn 2002).

Several AIS have been detected in Umpqua National Forest (UNF) including the submerged plant curly leaf pondweed (*Potamogeton crispus*) in Diamond Lake (Helliwell 2003; Salinas 1998; Sytsma and Pfauth 2006), and Clearwater Forebays number 1 and 2 (Unpublished GIS data from surveys conducted by EDAW, Inc. for PacifiCorp in 2006); and European ear snails in Lemolo Lake, Toketee Lake, Hemlock Lake, Ash Pond, Carmen Lake, and Beaver Swamp (Amy Rusk, Umpqua National Forest, personal communication, 7/12/2010). These species pose a high risk for spread to other waterbodies in the UNF. Other AIS have been detected near the UNF such as yellow floating heart (Howard 2012) and New Zealand mudsnails (Benson and Kipp 2012) and therefore pose a high risk to UNF waterbodies. Other AIS of concern in Oregon include rusty and red swamp crayfish (*Orconectes rusticus, Procambarus clarkii),* zebra and quagga mussels (*Dreissena polymorpha, Dreissena bugensis*) and the benthic algae rock snot (*Didymosphenia geminate*) (OISC 2010). Surveys conducted by the Center for Lakes and Reservoirs at Portland State University (CLR) during the summer of 2009 found no additional AIS in five UNF waterbodies, although Eurasian watermilfoil was detected in a pond near the UNF (Sytsma et al. 2010).

This report concerns a survey of 11 UNF waterbodies conducted by CLR during the summer of 2011. The main purpose of the surveys was to provide early detection of AIS plants, snails, bivalves and crayfish to inform rapid response actions. An additional goal of the surveys was to document the occurrence of native aquatic plant species.

SURVEY SITES

Waterbodies were selected for the survey based on two criteria: 1) they have not been surveyed recently, and 2) they have higher recreational use relative to other unsurveyed waterbodies in the UNF. Recreational activities such as boating and fishing are the most likely pathways for introduction to UNF waterbodies, although other pathways such as transport by waterfowl or fire suppression activities are possible. The eleven waterbodies surveyed during 2011 (Table 1; Figure 1) were selected after consultation with UNF personnel familiar with recreational use in the UNF. Seven of the selected waterbodies are accessible by road and four by short trail. Waterbodies ranged from

0.8 to 14 acres surface area and from 2474 to 5551 ft elevation. Sites located in each of the four UNF Ranger Districts were represented in the survey. PacifiCorp's North Umpqua Hydroelectric Project impoundments were excluded from the survey.

TABLE 1. UNF WATERBODIES SURVEYED FOR AQUATIC INVASIVE PLANTS, BIVALVES, AND GASTROPODS IN 2011.

Waterbody name	Surface area (ac)	Latitude (dd)	Longitude (dd)	Elev. (ft)	Date	Access method	Ranger district
Beaver Pond	2.0	43.37881	-122.56121	3156	8/16/11	Road & canoe	North Umpqua
Crawfish Lake	2.8	43.62500	-122.70385	3993	8/15/11	Trail & shoreline	Cottage Grove
Cultus Lake	5.8	43.12028	-122.96014	2474	8/24/11	Road & canoe	North Umpqua
Emile Sump	1.7	43.24677	-122.77884	4111	8/16/11	Road & canoe	North Umpqua
East Twin Lake	14.4	43.22889	-122.59187	5039	8/24/11	Trail & shoreline	North Umpqua
Lake in the Woods	4.0	43.21675	-122.72395	3018	8/16/11	Road & canoe	North Umpqua
Ranawipiti Pond	0.8	43.24440	-122.35709	3081	8/23/11	Road & canoe	Diamond Lake
Skookum Lake	10.9	43.16649	-122.33568	5551	8/23/11	Trail & shoreline	Diamond Lake
Skookum Pond	14.2	43.00923	-122.59726	3501	8/7/11	Road & canoe	Tiller
West Twin Lake	5.7	43.22841	-122.59598	5075	8/24/11	Trail & shoreline	North Umpqua
Willow Sump	2.0	43.25261	-122.79577	4012	8/16/11	Road & canoe	North Umpqua

METHODS

Aquatic plants were collected with a double sided thatch rake attached to a rope, observed through a viewing tube, or observed from shore or canoe. Survey areas were focused on access points; however, the perimeters of waterbodies were surveyed by canoe or on foot. Approximately one hour of survey effort was conducted at each site. Plants were identified to species in the field if possible, or returned on to the CLR lab on ice for identification. Voucher specimens were pressed and archived at CLR.

A cursory examination for crayfish, snails, and bivalves was conducted along the shorelines by turning over rocks or other structure. If the canoe was used for sampling, the canoe hull was thoroughly examined for attached snails and cleaned and dried between sites. Suspected AIS were preserved in 70% ethanol and transported to CLR for identification, and/or pictures of specimens were taken in the field. Temperature, dissolved oxygen, conductivity, and pH were measured with a Eureka Manta multiprobe sensor at a subset of the waterbodies along with Secchi transparency and maximum depth. The water quality data is available in Appendix A.

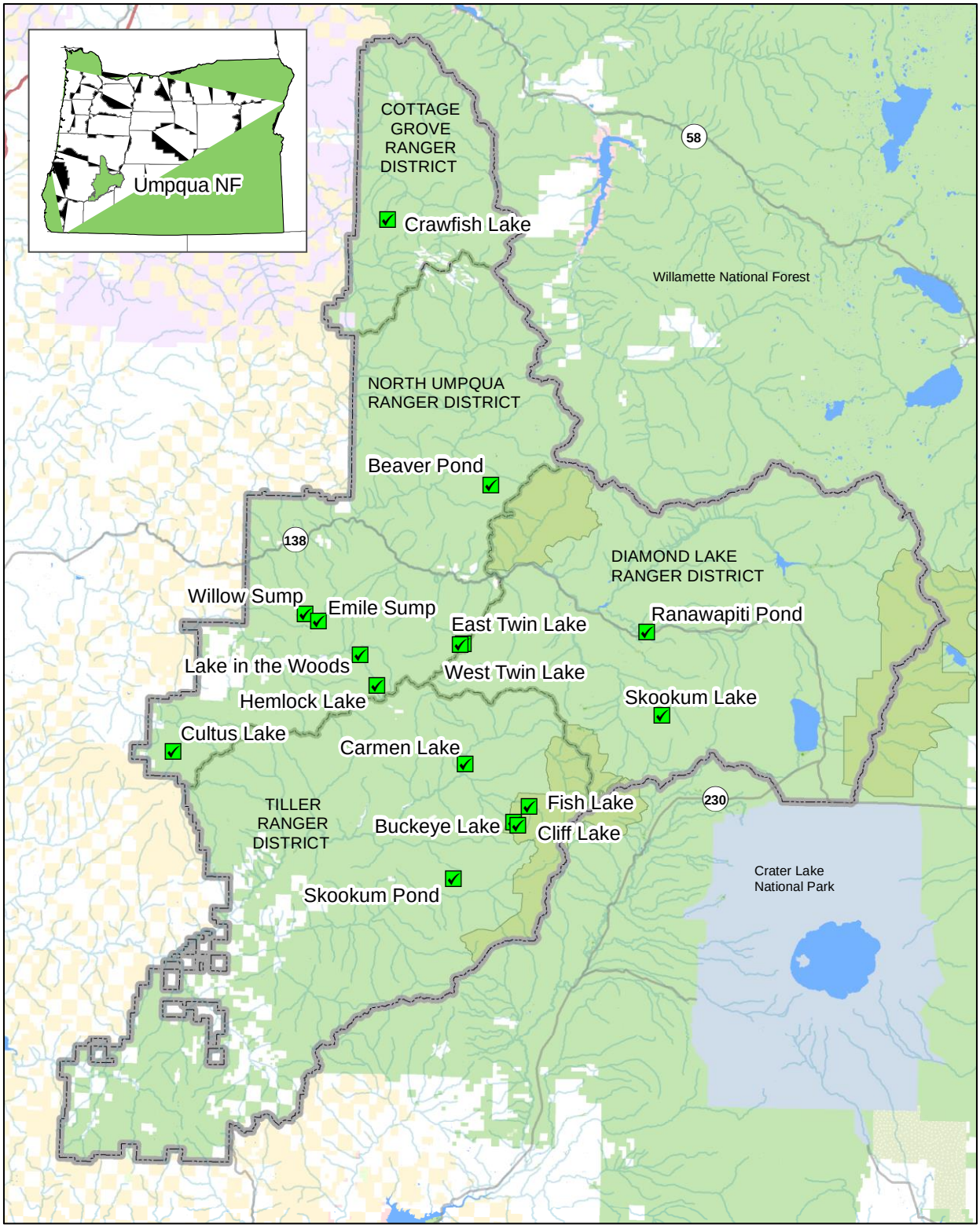

FIGURE 1. UMPQUA NATIONAL FOREST SITES SURVEYED FOR INVASIVE AQUATIC SPECIES SURVEY DURING 2009 AND 2011.

RESULTS

Dense beds of submerged aquatic plants were present throughout all waterbodies with the exception of Skookum Lake, East Twin Lake, West Twin Lake, and Crayfish Lake. Submersed plants were present in these lakes, but in a relatively sparse, patchy distribution. Aquatic Plant diversity ranged from 11 submerged and floating leaf species in Cultus Lake to three species in West Twin Lake and Emile Sump (Table 2). The most commonly encountered native species were bigleaf pondweed (*Potamogeton amplifolius*) and duckweed (*Lemna sp.*), which were each present at six of the eleven sites. At least one of the thin leaf pondweed species *Potamogeton foliosus* or *P. pusillus* were also present at six of the sites. Other common native species included floating-leaf pondweed (*P. natans*), narrow leaf bur-reed (*Sparganium angustifolium*), fontinalis moss (*Fontinalis sp.*), and the macroalgae *Nitella sp.* Several plant specimens could not be identified to species because morphological features such as mature flowers were not present at the time of the survey. There were enough features present, however, to rule out the possibility that the unidentified species were AIS of concern in Oregon. The only AIS plant encountered was a very dense stand of yellow floating heart (*Nymphoides peltata*) at Willow Sump which is located in the headwaters of the Little River, a tributary the North Fork Umpqua River.

One species of pebblesnail, one bladder snail, and one ramshorn snail species were collected from Beaver Pond, Ranawipiti Pond, and Crayfish Lake respectively. The specimens were not identified to species; however, there are no AIS of concern among these types of snails. The European ear snail (*Radix auricularia*), an AIS species documented in several other UNF waterbodies, was abundant in Beaver Pond which is located near the headwaters of Reynolds Creek, a tributary of Steamboat Creek. The only crayfish detected during the surveys was a native signal crayfish (*Pacifastacus leniusculus*) on the shoreline of Crayfish Lake.

TABLE 2. AQUATIC PLANT AND ANIMAL SPECIES COLLECTED FROM UNF LAKES AND PONDS DURING 2011 SURVEYS

Waterbody	Date	Scientific name	Common name	Status	Notes
Beaver Pond	8/16/2011	*Eleocharis acicularis*	Needle leaf spikerush	Native	
		Lemna sp.	duckweed	Unknown	
		Nitella sp.	nitella, brittlewort	Unknown	
		Potamogeton foliosus	leafy pondweed	Native	
		Potamogeton natans	floating-leaf pondweed	Native	
		Ranunculus aquatilis	water buttercup	Native	
		Radix auricularia	**European ear snail**	**AIS**	**Very abundant throughout the pond**
		Fluminicola sp.	pebblesnail	Unknown	
Crawfish Lake	8/15/2011	*Callitriche sp.*	water starwort	Unknown	No fruit present for identification to species
		Carex sp.	sedge	Unknown	
		Fontinalis sp.	fontinalis moss	Unknown	
		Lemna sp.	duckweed	Unknown	
		Ranunculus aquatilis	water buttercup	Native	Abundant
		Sparganium angustifolium	narrowleaf bur-reed	Native	
		Planorbidae sp.	Ramshorn snail	Unknown	
		Pacifastacus leniusculus	signal crayfish	Native	Pictures taken, specimen not collected
Cultus Lake	8/24/2011	*Callitriche sp.*	water starwort	Unknown	
		Carex sp.	sedge species 1	Unknown	
		Carex sp.	sedge species 2	Unknown	
		Fontinalis sp.	fontinalis moss	Unknown	
		Hipparus vulgaris	common mare's tail	Native	Very abundant
		Juncus sp.	rush	Unknown	
		Myriophyllum sp.	water milfoil	Native	Winter buds were present, but flowers were not. Species is either *M. sibiricum* or *M. verticillatum*
		Myriophyllum sp.	water milfoil	Native	No flower present. Species is *M. hippuroides* or a variation of the other unknown *Myriophyllum sp.* in Cultus Lake
		Nitella sp.	nitella, brittlewort	Unknown	
		Potamogeton amplifolius	bigleaf pondweed	Native	
		Potamogeton epihydrus	ribbonleaf pondweed	Native	Very abundant
		Potamogeton natans	floating-leaf pondweed	Native	Very abundant
		Potamogeton pusillus	small pondweed	Native	Very abundant
		Scirpus subterminalis	water bulrush	Native	
		Utricularia vulgaris	common bladderwort	Native	Very abundant

TABLE 2 (CONTINUED). AQUATIC PLANT AND ANIMAL SPECIES COLLECTED FROM UNF LAKES AND PONDS DURING 2011 SURVEYS

Waterbody	Date	Scientific name	Common name	Status	Notes
Emile Sump	8/16/2011	*Eleocharis acicularis*	needle leaf spike rush	Native	
		Potamogeton amplifolius	bigleaf pondweed	Native	Very abundant
		Potamogeton natans	floating-leaf pondweed	Native	Very abundant
		Sparganium angustifolium	narrowleaf bur-reed	Native	Abundant
East Twin Lake	8/24/2011	*Carex* sp.	sedge	Unknown	
		Eleocharis sp.	spikerush	Unknown	Possibly *E. acicularis*
		Isoetes sp.	quillwort	Unknown	
		Limosella aquatica	water mudwort	Native	
		Nuphar polysepala	spatterdock	Native	
		Potamogeton natans	floating-leaf pondweed	Native	
		Sparganium sp.	bur-reed	Native	*S. hyperboreum* or *S. natans*
Lake in the Woods	8/16/2011	*Lemna sp.*	Duckweed	Unknown	
		Nitella sp.	Nitella, brittlewort	Unknown	
		Potamogeton amplifolius	Bigleaf pondweed	Native	
		Potamogeton sp.	Pondweed	Native	Thin leaf sp., either *P. pusillus* or *P. foliosus*
		Typha latifolia	Common cattail	Native	
Ranawipiti Pond	8/23/2011	*Carex sp.*	Sedge	Unknown	Possibly *C. amplifolia*
		Carex sp.	Sedge	Unknown	Possibly *C. rostrata*
		Eleocharis ovata	Ovate spike rush	Native	
		Elodea canadensis	American waterweed	Native	
		Juncus sp.	Rush	Unknown	Possibly *J. balticus*
		Juncus sp.	Rush	Unknown	Possibly *J. bolander*
		Lemna sp.	Duckweed	Unknown	
		Nitella sp.	Nitella, brittlewort	Unknown	
		Potamogeton foliosus	Leafy pondweed	Native	
		Potamogeton natans	Floating-leaf or broadleaf pondweed	Native	
		Sparganium angustifolium	Narrowleaf burr reed	Native	
		Typha latifolia	Common cattail	Native	
		Physidae sp.	Bladder snail	Unknown	

TABLE 2 (CONTINUED). AQUATIC PLANT AND ANIMAL SPECIES COLLECTED FROM UNF LAKES AND PONDS DURING 2011 SURVEYS

Waterbody	Date	Scientific name	Common name	Status	Notes
Skookum Pond	8/7/2011	*Lemna sp.*	Duckweed	Unknown	
		Lycopus sp.	Water horehound	Unknown	
		Nitella sp.	Nitella, brittlewort	Unknown	
		Nuphar polysepala	Spatterdock	Native	Abundant throughout lake
		Potamogeton amplifolius	Bigleaf pondweed	Native	Degraded but abundant throughout lake
		Typha latifolia	Common cattail	Native	
Skookum Lake	8/23/2011	*Carex sp.*	Sedge	Unknown	
		Fontinalis sp.	Fontinalis moss	Unknown	
		Potamogeton amplifolius	Bigleaf pondweed	Native	
		Potamogeton pusillus	Small pondweed	Native	
West Twin Lake	8/24/2011	*Isoetes sp.*	Quillwort	Unknown	
		Sparganium sp.	Bur-reed	Native	*S. hyperboreum* or *S. natans*
		Sparganium sp.	Bur-reed	Native	Possibly *S. angustifolium*
Willow Sump	8/16/2011	*Callitriche heterophylla*	autumn water-starwort	Native	
		Chara sp.	Chara	Unknown	
		Fontinalis sp.	Fontinalis moss	Unknown	
		Lemna sp.	Duckweed	Unknown	
		Nymphoides peltata	**Yellow floating heart**	**AIS**	**Very abundant throughout the lake, approximately 0.5 acre infestation**
		Potamogeton amplifolius	Bigleaf pondweed	Native	
		Potamogeton sp.	Pondweed	Native	Thin leaf species *P. pusillus* or *P. foliosus*
		Sparganium angustifolium	Narrowleaf bur-reed	Native	

DISCUSSION

One AIS plant, *Nymphoides peltata* in Willow Sump, and one AIS snail, *Radix auricularia* in Beaver Pond, were detected during the 2011 surveys. The occurrence of *R. auricularia* in Beaver Pond was not unexpected since it has been detected in several nearby UNF waterbodies. In fact, it is more surprising that the species was detected at only one of the 11 surveyed lakes and ponds since *R. auricularia* is present in several of the more popular recreational waterbodies in the area (e.g. Toketee and Lemolo Lakes).

The detection of *N. peltata* in Willow Sump is more troublesome. *N. peltata* is a floating leaved rhizomatous aquatic plant native to Europe and Asia that was brought to the US as an ornamental plant. The species has a tendency to form a dense canopy which excludes native plants, creates stagnant water with low dissolved oxygen concentrations, and interferes with fishing and boating. Due to these impacts, *N. peltata* is currently listed as one of the "100 most dangerous invaders to keep out" by the Oregon Invasive Species Council (OISC 2010) and is listed as a Class "A" Designated Weed by the Oregon Department of Agriculture which is defined as "a weed of known economic importance which occurs in the state in small enough infestations to make eradication or containment possible; or is not known to occur, but its presence in neighboring states make future occurrence in Oregon seem imminent" (ODA 2011a). ODA recommends eradication or intensive control of Class "A" weeds when and where found.

The infestation at Willow Sump is very dense and extensive at approximately a half acre. Because of the large size of the patch, *N. peltata* has likely been present for a number of years. It is difficult to estimate when the plant was introduced, however, because once established, plants spread rapidly via runners, broken runners that have established roots, and plantlets developed at flowering stems (Brock et al. 1983). Dispersal via seeds is less likely for introduced populations, which are often mono-clonal, due to poor seedling viability (Larson 2007). Larson found that introduced populations exhibited vegetative reproduction only in 6 of 7 lakes studied, and each of the lakes contained only one genotype. In the one population which exhibited multiple genotypes and sexual reproduction, dispersal via vegetative reproduction still dominated. Larson's findings suggest that dispersal of *N. pletata* seeds is less of a concern for management than movement of vegetative material. In particular the ornamental flowers and vegetative material can be a temptation for recreational visitors to transport to other ponds, lakes, or water gardens.

Two other AIS plants were not detected during this survey which had a high likelihood of occurrence. Curly leaf pondweed (*Potamogeton crispus*), a submerged plant which has been present in Diamond Lake (Salinas 1998) and two of PacifiCorp's North Umpqua Project impoundments (PacifiCorp, personal communication) since the 1990s, was not detected in the surveyed waterbodies. Eurasian watermilfoil (*Myriophyllum spicatum*), a submerged ODA "B" Designated Weed, has a limited distribution in all western Oregon counties (ODA 2011b), but was not detected during this survey.

MANAGEMENT RECOMMENDATIONS

Since vegetative reproduction is likely the primary means for spread of *N. pelata* within Willow Sump and to other waterbodies, special care must be taken if mechanical harvesting is selected as the treatment for the infestation. Fragmentation of vegetative material and unintended dispersal within the pond while harvesting can actually increase the rate of spread. In addition, harvesting may not be successful. A study in India found that the survival of another species of *Nympoides* (*N. cristatum*) was not impacted by clipping (Middleton 1990). Other eradication and control options are limited: There are also no known insect or fish herbivores that are effective at controlling populations; drawdown and freezing has been ineffective; and no single herbicide has been effective (Willey and

Langeland 2011). Applications of various combinations aquatic herbicides have been successful for short term control, but not long term control of populations.

Signs instructing boaters and fishermen to clean their trailers, boats and gear before and after launching should be installed at all boat ramps and unofficial access point. Priority should be given to waterbodies with known infestations of AIS such as Willow Sump and Beaver Pond. Signage should be consistent with the CLEAN-DRAIN-DRY message advocated by the Western Regional Panel Aquatic Nuisance Species (Zook and Phillips 2009). Staff within the USFS and other agencies in the region should be familiar with high priority IAS, know the proper channels communicate sightings of suspected IAS, and the importance of rapid communication. Outreach materials for many IAS are available from ODA's Noxious Weed Control Program or from PSU-CLR. Finally, continued monitoring for the early detection of new infestations of AIS plants of concern (Table 3) and animals should be continued to allow the opportunity for rapid response while less expensive and more effective control and eradication methods are available.

TABLE 3. IAS PLANTS OF HIGH CONCERN FOR SPREAD AND/OR INTRODUCTION INTO OREGON WATERBODIES.

Scientific name	Common Name	ODA Noxious Weed List Rating
Butomus umbellatus	flowering rush	A
Cabomba caroliniana	fanwort	unrated
Egeria densa	Brazilian egeria	B
Hydrilla verticillata	hydrilla	A
Iris pseudacorus	yellow flag iris	B
Ludwigia spp.	floating water primrose	B
Lythrum salicaria	purple loosestrife	B
Myriophyllum aquaticum	parrotfeather	B
Myriophyllum heterophyllum	variable-leaf milfoil	unrated
Myriophyllum spicatum	Eurasian water milfoil	B
Nymphaea odorata	fragrant waterlily	unrated
Nymphoides peltata	yellow floatingheart	A
Phragmites australis ssp. *australis*	common reed	A
Potamogeton crispus	curly leaf pondweed	unrated
Trapa natans	European water chestnut	A

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LITERATURE CITED

Benson, A.J. and R.M. Kipp. 2012. *Potamopyrgus antipodarum*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1008 Revision Date: 7/6/2011.

Brock, T.C.M., G.H.P Arts, I.L.M. Goossen, and A.H.M. Rutenfrans. 1983. Structure and annual biomass production of *Nymphoides peltata* (Gmel.) O. Kuntze (Menyanthaceae). Aquat. Bot. 17: 167–188.

Helliwell, R., A. Hardman, C. Emerson, and G. Dour. 2003. Aquatic macrophyte inventory of Diamond Lake. Unpublished report, Umpqua National Forest, Roseburg, OR.

Howard, V. 2012. *Nymphoides peltata*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=243 Revision Date: 4/4/2007.

Kipp R.M. and A.J. Benson. 2012. *Radix auricularia*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1012 Revision Date: 6/3/2010.

Larson, D. 2007. Reproduction strategies in introduced *Nymphoides peltata* populations revealed by genetic markers. Aquatic Botany 86:402–406

Middleton, B.A. 1990. Effect of water depth and clipping frequency on the growth and survival of four wetland plant species. Aquat. Bot. 37, 189–196.

Oregon Department of Agriculture. 2011a. Noxious weed policy and classification system 2011. Oregon Department of Agriculture Noxious Weed Control Program.

Oregon Department of Agriculture. 2011b. ODA Plant Division, Noxious Weed Control, Eurasian watermilfoil. Retrieved January 9, 2012, from http://egov.oregon.gov/ODA/PLANT/WEEDS/profile_eurasianwatermilfoil.shtml

Oregon Invasive Species Council. 2010. 100 most dangerous invaders to keep out. Retrieved January 9, 2012 from http://www.oregon.gov/OISC/most_dangerous.shtml

Rejmánek M, Pitcairn MJ. 2002. When is eradication of exotic plant pests a realistic goal? Pages 169–176 in Veitch CR, Clout MN, eds. Turning the Tide: The Eradication of Invasive Species. Gland (Switzerland): IUCN.

Salinas, J. 1998. A Cascades lakes limnological survey, summer, 1996 – 1997. Report CAS-9801, Rogue River Community College, Grants Pass, OR.

Sytsma, M. and M. Pfauth. 2006. 2005 Diamond Lake Submersed Aquatic Vegetation Survey. Report prepared for the U.S. Forest Service, Umpqua National Forest. Portland State University, Center for Lakes and Reservoirs, Portland, OR.

Systma, M., R. Miller, and R. Shrestha. 2010. Non-native invasive aquatic plant and mussel survey of six Umpqua National Forest area lakes. Final report prepared for the USDA Umpqua National Forest. Portland State University, Center for Lakes and Reservoirs, Portland, OR.

Willey L.N. and K.A. Langeland. 2011. Aquatic Weeds: Crested Floating Heart. Document SS-AGR-344, Agronomy Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Retrieved January 10, 2012 from http://edis.ifas.ufl.edu/pdffiles/AG/AG35400.pdf

Zook B, and S. Phillips. 2009. Recommended uniform minimum protocols and standards for watercraft interception programs for dreissenid mussels in the western United States. Western Regional Panel on Aquatic Nuisance Species. Retrieved January 12, 2012 from http://www.100thmeridian.org/Recommended-Protocols-and-Standards-for-Watercraft-Interception-Programs-for-Dreissenid-Mussels-in-the-Western-United-States.pdf

APPENDIX A. PHYSICAL AND CHEMICAL CHARACTERISTICS OF SURVEY LAKES.

Waterbody	Date	Maximum depth (ft)	Secchi (ft)	pH (S.U.)	Cond. (µS/cm)	DO (mg/l)	DO (%_sat)	Temp. (deg C)
Beaver Pond	8/16/11	NA	3.4	NA	NA	NA	NA	NA
Crawfish Lake	8/15/11	NA	NA	NA	NA	NA	NA	NA
Cultus Lake	8/24/11	NA	NA	7.3	56	10.4	121	17.9
Emile Sump	8/16/11	NA	3.7	6.9	38	6.3	77	18.3
East Twin Lake	8/24/11	50*	NA	NA	NA	NA	NA	NA
Lake in the Woods	8/16/11	6.8	> max z.	9.8	43	14.6	185	21.3
Ranawipiti Pond	8/23/11	NA	> max z.	NA	NA	NA	NA	NA
Skookum Lake	8/23/11	20*	NA	NA	NA	NA	NA	NA
Skookum Pond	8/7/11	9.5	4.7	7.1	80	10.7	143	23.5
West Twin Lake	8/24/11	30*	NA	NA	NA	NA	NA	NA
Willow Sump	8/16/11	8	> max z.	7.0	42	8.8	104	16.1

* Rinella, J.F. 1979. Lakes of Oregon, Volume 6, Douglas County. Open-File Report, United States Geological Survey, Portland, Oregon. 123 pp.